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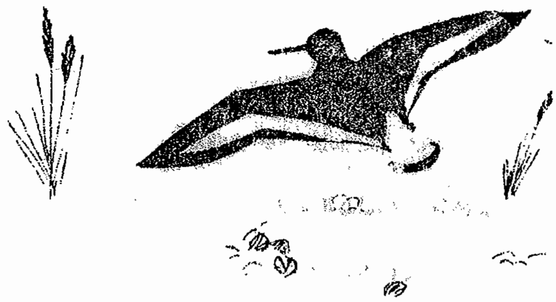

THE ASSESSMENT OF COASTAL HABITAT RESOURCES FROM AERIAL PHOTOGRAPHY

2. Mapping and Assessment of Saltmarsh Vegetation Resources

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2. Mapping and Assessment of Saltmarsh Vegetation Resources

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ABSTRACT

In Paper 1 detailed methods are given for production of general habitat map of Holkham N.N.R. Similar techniques are now used to produce a vegetation map of the saltmarsh areas on the reserve. A method of quantitative field verification is used to assess the interpretation of the photography and this then enables more accurate keying of the vegetation types. Vegetation resources are measured in terms of areas using a dot grid method. An estimation of cost and time commitment for such a survey is also given. These techniques are intended for the ecologist who has neither the equipment nor the expertise to tackle more sophisticated methods of photo-mapping.

Introduction

A method for the assessment of major coastal habitat resources has been outlined in an earlier paper. In this study, similar but more sophisticated techniques have been used to provide a vegetation map and to assess the vegetation resources. As before the techniques are intended, not for persons experienced in aerial survey, but for ecologists. Some of the more conventional methods of plotting are avoided since they are rather more complex than needed for simple vegetation survey. The errors incurred in using the more simple methods are quantified to define our limits of accuracy.

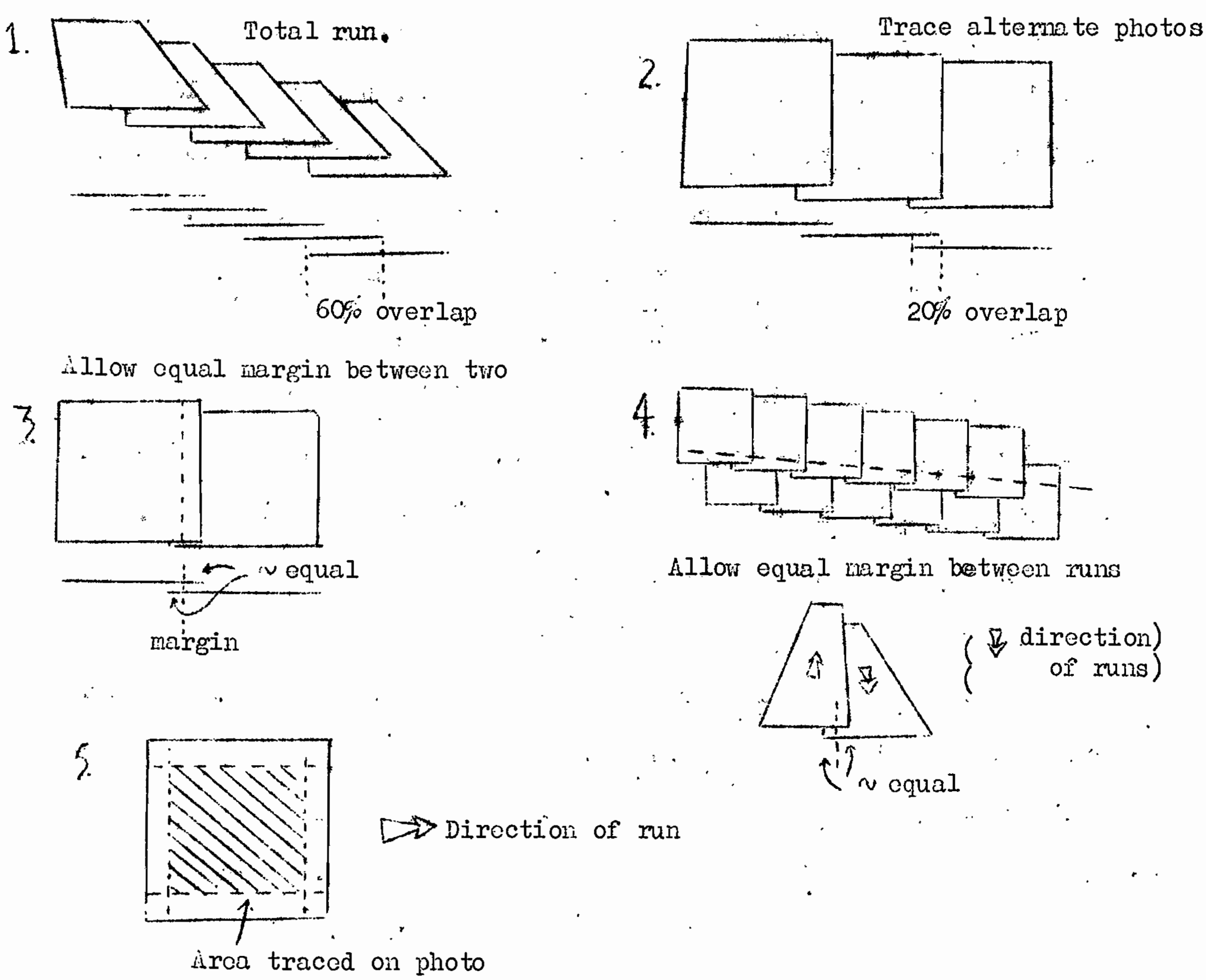
Previously the whole area of Holkham National Nature Reserve was mapped but attention is now centered on the saltmarsh area between Wells and Stiffkey.

The aim was to map the vegetation types seen on the photographs, to evolve a method of ground analysis of these 'communities' and then to assess the resources in terms of areas.

The term community when used is in the general sense of plants occurring together, not in a Phytosociological sense.

Methods

The method is essentially that used in the first part of this study. Full details will only be given where modification has been necessary to produce the more complex map. As before the 1:10,000 photomosaic was used as a base for the map. However, tracing was from the original 9 x 9" photographs, using a Cassella mirror stereoscope. This helps not only by giving 3-D vision but also allows one eye to see a photograph not obscured by the tracing sheet, a great help when tracing. Every other photograph in a run was traced. This gives a 20% overlap between photographs leaving a margin which is shared equally between adjacent photos. Overlap between adjacent runs is also shared equally between them. This means that only the centre of a photograph is traced. (Distortion is greatest at the edges of a photo). The diagram below may make this more clear.



The smallest units that can be mapped without the pencil outlines virtually running together are about 1 mm. in width. This allows us to map most major vegetation discontinuities, and the larger creeks, in fact units down to about 10 m. width on the ground. Most salt pans were well below this size and so none were mapped. Tracing of detail from the flats was limited to major creek patterns and sand bars. Patterns in the sediments were not relevant to this study and were omitted.

Any discontinuities on the air photos thought to be due to vegetation changes were mapped. During early stages it was unnecessary to relate these discontinuities to actual vegetation types. It is a help to know what to expect in terms of these, but one should be able to select the different zones on the basis of their tones and textures and later ascribe species or communities to them.

Some difficulty may be experienced when drawing boundaries due to some of them appearing to fade out. However, the zone being drawn must be enclosed, and use of stereo will help locate the boundary along its most appropriate line, and hence close the 'loop'.

The individual tracings must then be fitted to the base map. To simplify this the uncontrolled mosaic is used to give a base. Distortion of this mosaic on such a flat terrain was shown to be very small over areas larger than that under study in this vegetation map. (See Habitat Paper - C.E.R.S. Research Paper 1).

Reference points are traced from the photo-mosaic onto a large tracing sheet to orientate the photographs correctly. There should be at least four such points or more per photograph, this means that they should lie approximately on a 10 cm. grid. Points that are easily recognised are best used, characteristic bends in creeks, sea-walls, anything that can be readily recognised. This means that when the 9 x 9" tracing is placed under the main tracing sheet it can be positioned and orientated correctly.

It may be found that due to distortion a tracing does not fit exactly, say it is too large. Then it will be necessary to compress that detail into the smaller space.

Compression or expansion will only involve 2-3 mm. over the 200 mm. width of tracing and so may represent a distortion of 1-1½%.

Interpretation

By the time all the tracing has been completed one should be able to recognise a number of distinct units of vegetation. Knowledge of the site will probably enable one to have a good guess as to what these units represent in terms of vegetation. It will also enable one to separate more easily two vegetation units with similar tonal qualities. But, for any person not totally familiar with the types of vegetation present, a field visit will be essential. The use of the stereoscope is also important at this stage as the emphasis of texture greatly helps interpretation. Interpretation is initially onto the individual tracings and then onto a True-to-Scale copy of the main tracing.

After interpretation a simple key was constructed:-

Black	Pines
Blue	Sand-dune/Shingle
Red	Agropyron banks
Pink	Juncus maritimus marsh
Yellow	Agropyron pungens marsh
Lt. Green	Festuca rubra marsh
Mauve	Suaeda fruticosa marsh
Turquoise	Halimione marsh
Dk. Green	Limonium marsh
Lt. Brown	Puccinellia marsh
Grey	Halimione pioneer marsh
Dk. Brown	Aster/Spartina marsh

Verification

The extremes to which one takes verification depend upon the intended uses of the map. This survey incorporated a time consuming and detailed vegetation survey. This was largely to show that one could rely upon the method as a whole.

The first stage of verification is important unless the site is known well already. This should involve, as with the Habitat map, 'look-see' verification that sites are correctly interpreted. Any sites that are in doubt should be visited, but also other sites thought to be correctly interpreted. The time spent on 'look-see' verification depends on the likelihood of error. Sites known well, easily interpreted and with simple communities need less checking than complex little-known sites. If interpretation presented few problems, and the early verification confirmed one's interpretation then there would seem little need for spending much time in the field.

After this stage corrections are made to the map. It should also be possible to provide a much more accurate key to the 'communities'.

For many purposes this sort of verification may suffice. However, for the Holkham Vegetation Survey it was considered important to assess the **technique's** potential for use on other sites. Hence a method of field verification was used to give a quantitative assessment of each saltmarsh vegetation unit.

The method of assessment had to be fairly quick and involve only a small amount of sampling. It had to be objective since, with a preconceived idea of the likely vegetation types, bias could become serious with more subjective methods.

It was decided to sample ten sites of each 'community' or if there were less than ten, to sample all. Samples were taken from the centre and extremes of the range of a community, in a **regular** pattern on the map. These were then marked on the photograph in about the centre of each area to be sampled. The point at which quadrats were to be taken was pin-pointed with an arrow head of masking tape. It was ensured that the point fell onto a representative part of the associes (e.g. not a **creek**). With this point marked, the sample site in the field was determined to within 1 or 2 metres.

Presence or absence of species within a quadrat seemed a quick and easy method of recording. Initially it was thought that a 1 m. quadrat gridded into 100 squares would suit the survey. However, within a community there is generally a micro-pattern of species such that a small quadrat will record different results in different areas. The micro-pattern was not our interest. We wanted a record of the overall species composition of that community. So rather than sample from a metre quadrat it was decided that the sample area should span more ground. We chose to use a quadrat area 10 metres long, 10 cm. wide, that is still 1 m^2 but rectangular. A 1 metre long frame was used and this was cart-wheeled along a straight line for nine turns. The quadrat was divided into ten $(10cm)^2$ squares. Quadrats were positioned by a throw when at the site marked on the photograph, and orientated along the long axis of the community. Major irregularities such as pans or creeks were, however, avoided. Presence or absence of species within each of the 100 squares was counted and the mean scores for all sites of that community were evaluated.

The communities are listed with the more terrestrial sites to the left, pioneer marsh to the right. The species are listed in approximate order of their levels on the salt marsh though their order is arranged on the basis of floristic data rather than any true height measurements.

Frequency values based on mean presence value in sample of 100 x 10 cm^2 contiguous quadrats

	Juncus marsh	Agropyron marsh	Suaeda marsh	Festuca marsh	Halimione marsh	Limonius marsh	Puccinellia pioneer marsh	Halimione Pioneer Marsh	Spartina Aster Marsh
	Pink	Yellow	Mauve	Lt. Green	Turq.	Dk Green	Lt Brown	Grey	Dk Brown
No. of sites	3	13	10	10	9	10	9	4	6
Urtica dioica	+								
Juncus maritimus	100								
Senecio jacobaea	15	+							
Picris echioides	11	2							
Sonchus arvensis	1	+							
Atriplex hastata	4	1	+						
Atriplex littoralis		2	+						
Beta maritima			+						
Silene maritima			1						
Limonium bellidifolium			1	1					
Frankenia laevis				+					
Plantago coronopus				5					
Juncus gerardii				3					
Cochlearia spp.	+		4	+					
Agrostis stolonifera	12	1	1	27					
Suaeda fruticosa	27	13	69	1	1				
Agropyron spp.	26	60	66		4				
Artemisia maritima	5	15	2	2	7				
Festuca rubra	39	44	8	66	31				
Limonium binervosum	+	1	2	3	+				
Glaux maritima		7		16	1				
Plantago maritima		20	2	37	31	34			
Trigolochin maritima		5		19	28	60	11		
Spergularia media		+	5	2	12	11	3		
Armeria maritima		+	2	10	25	41	3		
Halimione portulacoides	23	25	26	20	70	19	58	78	2
Limonium spp.	14	21	1	54	74	88	37	9	2
Puccinellia maritima		13	13	34	66	75	79	62	52
Suaeda maritima		1	9	4	32	39	45	49	28
Aster tripolium		4	1	5	46	31	40	20	69
Salicornia spp.		+	2	27	39	86	66	34	97
Spartina anglica						2	21	2	42

Species lists were also taken for 12 sand-dune and 7 marsh bank sites. Both are essentially terrestrial sites and were not examined quantitatively. Three of the marsh bank sites where the bank had been constructed for marsh reclamation were very low and in fact were typical of normal <u>Agropyron</u> marsh. They were thus sampled quantitatively and included in the Agropyron marsh results.

Below are the total species lists for the two habitats:-

Sand dune (No. of sites sampled - 12)

Agropyron pungens
Agrostis stolonifera
Aira praecox
Ammophila arenaria
Armeria maritima
Atriplex hastata
Bryonia dioica
Carex arenaria
Carex riparia
Cerastium sp.
Cirsium arvense
Cirsium vulgare
Cochlearia sp.
Dactylis glomerata
Epilobium angustifolium
Eryngium maritimum
Festuca rubra
Galium verum
Glaux maritima
Halimione portulacoides
Holcus lanatus
Honkenya peploides
Hypochaeris radicata
Leontodon autumnalis
Limonium binervosum
Picris echioides
Poa pratensis
Rumex acetosella
Rumex crispus
Senecio jacobaea
Senecio sylvaticus
Silene alba
Silene maritima
Sonchus arvensis
Suaeda fruticosa
Urtica dioica

Marsh banks (No: of sites sampled - 7)

Achillea millefolium
Agropyron pungens
Agropyron repens
Agrostis stolonifera
Anthriscus sylvestris
Arrhenatherum elatius
Artemisia maritima
Atriplex hastata
Atriplex littoralis
Bellis perennis
Beta maritima
Cakile maritima
Cerastium fontanum
Cerastium glomeratum
Cirsium arvense
Cirsium vulgare
Convolvulus arvensis
Crataegus monogyna
Cynosurus cristatus
Dactylis glomerata
Daucus carota
Epilobium angustifolium
Festuca rubra
Festuca arundinacea
Galium aparine
Helictotrichon pratense
Heracleum mantegazzianum
Heracleum sphondylium
Holcus lanatus
Leontodon autumnalis
Lolium perenne
Lotus corniculatus
Odontites verna
Phleum bertolonii
Phleum pratense
Picris echioides
Plantago coronopus
Plantago lanceolata
Plantago media
Poa angustifolia
Ranunculus repens
Rosa canina(agg.)
Rubus fruticosus
Rumex crispus
Senecio jacobaea
Smyrnium olusatrum
Sonchus arvensis
Stellaria alsine
Tragopogon pratense
Trifolium arvense
Trifolium campestre
Trifolium dubium
Trifolium pratense
Trifolium repens
Ulex europaeus
Urtica dioica
Vicia sativa

Discussion

To assess the results fully it is necessary to realise some of the limitations of the methods used. Firstly, presence or absence studies in units as large as 10 x 10 cm., are not sufficiently sensitive to differentiate between species of dominant cover and other species which are of lower cover but well distributed. Both will score high values. In not being directly related to cover it is harder to relate to the photography which relies mainly upon ground cover for its tonal qualities.

A second limitation of the method is that insufficient sites were sampled to get a full picture of the variety within and between 'communities'.

Despite these drawbacks the table of results shows quite clearly that the photography is picking out distinct vegetation units. Furthermore the units are those that are likely to be selected visually in the field.

It is also interesting that many of the units compare well with those recognised by Beeftink (1962) in a phytosocialogical classification of salt marsh. For example the <u>Halimione</u> marsh (turquoise) compares with his <u>Halimionetum portulacoidis</u>, the <u>Limonium</u> marsh (dark green) with his transition from <u>Puccinellietum maritimae</u> to <u>Halimionetum portulacoidis</u>.

So it seems that one can pick out salt marsh vegetation units from aerial photography which are comparable with obvious vegetational differences on the ground and may furthermore have some phytosociological meaning.

There are many possible sources of error that can go into mapping from aerial photographs and any resource assessment made from the map. To try and quantify these would involve a major survey of an area and without this it is necessary for the individual to try to estimate the importance of the errors. Some of the major error sources are listed below:-

1. Incorrect interpretation

This is probably the biggest single source of error and one of the easiest to assess. Some sites are recognised easily and so rarely classified wrongly. Other sites may be more difficult to recognise. In the Holkham survey the biggest error was made in confusing *Festuca rubra* type marsh with *Agropyron pungens*. Small quantities of *Agropyron* scattered on isolated hummocks gave the overall *Festuca* marsh some of the appearance of Agropyron marsh. This should have been realised in the 'look-see' verification but was not and so the quantitative data for *Agropyron* marsh shows more similarity to *Festuca* marsh than is truly the case. Correction on later maps has reduced this error but since quantitative verification was intended to describe the Stage 1 map the values are tabulated without omission of wrongly interpreted sites. Incorrect interpretation concerned 3 of the 13 *Agropyron* sites.

The areas shaded turquoise and green were very similar except that *Halimione* was important, often visually dominant in the former, but only scattered in the latter. On the basis of *Halimione* score there seemed to be only one site misplaced of the 20 sites examined between the two 'communities'. Most other sites fitted well into their appropriate classification.

Most misinterpretations could have been discovered with just a little longer spent on the preliminary reconnaissance, and errors from this source thus reduced greatly.

2. Variation within communities

Most communities have some species which are always present. On the basis of these they can be recognised. Other important species may or may not be present. To predict the occurrence of these species from 1:10,000 photography is probably not possible other than by knowledge of their growth in relation to topography (e.g. creeks, banks etc.) To assess the variation quantitatively would involve many more quadrats than have been sampled to date, and is not necessary for a general vegetation map.

3. Boundary Errors

In many vegetation transitions there is no abrupt boundary but a continuum between two communities. This makes mapping the outlines of a community very difficult. However, in intertidal regions boundaries, related to tidal levels and other closely confounded factors are often much more distinct. (e.g. *Suaeda fruticosa* at High Water Springs, *Limonium* marsh just above Mean High Water). Little difficulty was found in drawing definite outlines around vegetation units.

4. Lens distortion, Camera tilt, Plane height changes.

These have all been discussed in the earlier Habitat mapping Paper. Errors over the small flat area under study and the low number of photographs are very small in relation to other error sources.

Even in the earlier study over a much larger area these sources of error represented less than $\pm$ 1% of total area.

Keying the Communities

From the results of the survey it has been possible to make up a rather more elaborate and meaningful key. So as to keep the key simple up to three of the perennial species with scores averaging over 30/100 were used to define each community.

To describe the community more accurately, quadrat sites that were wrongly classified were omitted for the purpose of obtaining mean scores. The key on the following page was produced.

Once the areas had been corrected and keyed the final task was to measure them. The dot grid method described in the Habitat paper was chosen as being suitable for the complex, highly dissected areas on the vegetation map. As in the earlier study it was decided to work to $\pm$ 5% error on area estimation with 90% confidence. The areas to be measured were somewhat smaller than previously so a new 1 dot/cm^2 grid was constructed. For the very small areas of <u>Juncus</u> and Pines a grid of 25 dots/cm^2 was used. As before the grid was counted several times, moving randomly between each count until the standard error was lower than 5% of the mean. The results are tabulated on page 17.

	NO.	COLOUR	COMMUNITY	CHARACTERISTIC * SPECIES	FREQUENCY	NOTES
TERRESTRIAL	1	Black	Wooded sand-dune	Pines	NO QUANTITATIVE DATA FOR TERRESTRIAL SPP.	Introduced Corsican Pines
	2	Blue	Sand-dune/shingle grassland	Ammophila or Carex arenaria		Mixed dune and shingle communities
	3	Red	Marsh banks with tall grasses	Agropyron spp.		Mixture of strand-line and terrestrial spp.
INTERTIDAL SALT MARSH	4	Pink	Dune-slack/salt marsh transition	1 Juncus maritimus 2 Festuca rubra	100 39	Terrestrial and salt marsh species
	5	Mauve	Marsh strandline with shrubs	1 Suaeda fruticosa 2 Agropyron pungens	69 66	Dense often impenetrable Suaeda
	6	Yellow	High level tall grass marsh	1 Agropyron pungens 2 Festuca rubra	60 44	Some overlap between these communities with Agropyron and Festuca often together
	7	Light green	High level short grass marsh	1 Festuca rubra 2 Limonium spp. 3 Puccinellia	66 54 34	
	8	Turquoise	Mid-level marsh with herbs and dwarf shrubs	1 Limonium spp. 2 Halimione 3 Puccinellia maritima	75 70 66	Differs from 9 in that Halimione abundant. Often associated with creeks
	9	Green	Mid-level woody perennial marsh	1 Limonium spp. 2 Puccinellia maritima 3 Triglochin maritima	88 75 60	Short dense turf with typical salt marsh herbs
	10	Light brown	Low level short grass marsh	1 Puccinellia 2 Halimione 3 Aster	79 58 44	Maturing pioneer marsh tending towards 8 and 9 in species content
	11	Grey	Low level marsh with shrubs	1 Halimione 2 Puccinellia maritima	88 54	Dense stands of Halimione with few other species
	12	Dark brown	Pioneer marsh with short lived perennials	1 Aster 2 Puccinellia 3 Spartina	69 52 42	True pioneer marsh

*Only Perennial species with frequency over 30 are listed, to a maximum of three per community. (Frequency is given by mean no. of 10 cm. squares occupied out of 100).

Results of Dot Area Measurement

Table 4

	$\bar{x}$	SD	N	SE	t	Error	%
Black	48.16	2.40	6	0.98	2.02	1.98	4.1*
Blue	21.00	1.26	6	0.51	2.02	1.03	4.9
Red	8.06	2.45	104	0.24	1.67	0.40	5.0
Pink	15.06	1.64	17	0.40	1.75	0.70	4.7*
Yellow	38.33	3.64	15	0.94	1.76	1.67	4.3
Mauve	13.13	3.06	61	0.39	1.67	0.65	5.0
Light Green	11.97	1.80	29	0.33	1.70	0.56	4.7
Turquoise	261.50	8.35	4	4.18	2.35	9.82	3.8
Dark Green	121.17	6.11	6	2.49	2.05	5.10	4.2
Light Brown	36.17	4.32	18	1.02	1.74	1.77	4.9
Grey	11.27	1.56	26	0.31	1.71	0.53	4.7
Dark Brown	89.6	2.51	5	1.12	2.13	2.39	2.7
Total	631.67	4.51	3	2.61	2.92	7.61	1.2

* 25 dots/cm^2 grid, others at 1 dot/cm^2

To scale the map, distances between fixed points (e.g. bends in sea wall, buildings) are measured both on the photomosaic and on an OrdnanceSurvey map (the larger the scale the better). Several measurements in different orientations are taken so that a mean scale can be calculated.

The Vegetation Map was 2.427 times as large as the 2½" O.S. map; in other words at a scale of 1:10302. So:-

1 cm. of air-map = 103 m. on the ground

1 cm^2 " " = 10613 m^2 on the ground

= 1.0613 hectares

Dot areas can now be converted to hectares.

Community areas in hectares

Colour	Community	Area (Ha)
Black	Wooded sand dune (pines)	2.0
Blue	Sand dune/shingle grassland	22.3
Red	Tall grass marsh banks (*Agropyron* spp.)	8.6
Pink	Dune slack/salt marsh transition (*Juncus maritimus*)	0.6
Yellow	High level tall grass marsh (*Agropyron pungens*)	40.7
Mauve	Marsh strandline with shrubs (*Suaeda fruticosa*)	13.9
Light Green	High level short grass marsh (*Festuca rubra*)	12.7
Turquoise	Mid level marsh with herbs and dwarf shrubs (*Halimione*)	277.5
Dark Green	Mid level herbaceous marsh (*Limonium spp.*)	128.6
Light Brown	Low level short grass marsh (*Puccinellia*)	38.4
Grey	Low level pioneer marsh with shrubs (*Halimione*)	12.0
Dark Brown	Pioneer marsh with short lived perennials (*Aster*)	95.1
Total area	Overall Count	670.4
" "	Sum of Individual counts	652.4

(Species in brackets are those most characteristic of the community)

A comparison between the total area measured by dot counts and the sum of the individual units gives a difference of 2.7%, well within the allowable error.

Time/Manpower Investment

Equipment

The only major piece of equipment required for this method of map production is a mirror stereoscope. Other drawing materials are much according to preference but some mention of these has been made in the earlier Paper.

Cost

The main cost for such a study is in terms of man-power. Photomosaics are expensive and one is unlikely to have one made up especially for this task. The method is generally intended for use on already existing photography. The cost of other materials is minimal unless mass-production is required.

Manpower

Mapping can be relatively quick quantitative verification and analysis of data makes the complete job a rather lengthy one. To assist planning an attempt is made to fit a time scale to the stages of this sort of study. The times given are estimated on the assumption that problems will not arise. It is up to the individual worker to assess sources of delay (e.g. due to tidal inaccessibility) and allow for these. The times are given for an area like Holkham of about 600 hectares.

(A) Map Production

1 Preliminary field acquaintance	1 day
2 Fitting margins to photos, tracing	4 days
3 'Look-see field verification	2 days
4 Correction, shading tracings	4 days
5 Transfer to base map, inking in	3 days
6 Shading	2 days
7 Titles, key, labels etc.	2 days
8 Area measurement	3 days

Total time for map production is 21 days, 1 working month. This will vary for many reasons and can only be taken as approximate.

(B) Field Verification

9 Quantitative field verification	10 - 15 days
10 Data analysis	2 - 5 days
11 Key production, correction, reshading	5 - 10 days

Quantitative verification, data analysis, and correction increases the time considerably (20-30 days). Probelms of access, weather etc. will increase this.

Conclusions

The mapping of salt marsh communities proved well within the resolution of 1:10,000 aerial photography. The communities recognised agreed well with those one would pick on the ground, and also stood up to the test of quantitative verification. Area measurement, using a dot grid, was fairly quick and easy despite the complexity of the map, and gave a useful method of resource measurement. A scale of conversion of presence or absence data to cover values would enable resources of single species to be estimated. In fact, it might have been better to use a method more readily related to cover to start with.

Quantitative verification, as was hoped, proved unnecessary for production of a simple outline map. The results yielded by the quadrat data served mainly to show the interpretation to be generally acceptable. Whether or not this would apply with other maps of other areas remains to be seen. It seems very likely that with other habitats as simple as salt marsh, quick and accurate maps could be produced without the very time consuming quadrat measurement. However, since quadrats were counted, a quantitative key was provided for the map.

The method provides a useful technique for survey of remote areas and also for study of vast areas in a short time. Although not 100% accurate the use of mosaics for resource assessment is fairly quick and good enough for many purposes.

The map is also of conservation value in locating and assessing important plant resources. For example, the quantities of *Juncus maritimus* marsh can be seen to be very small and the consequences of loss of even a small area of this might be more significant than of many hectares of *Limonium* marsh. We can also assess the value of the marshes to waders and wildfowl in terms of major feeding areas, which will tend to be in the pioneer zones, roosting areas, which would be over the higher marsh, and refuge and nesting areas on the dune and *Agropyron* banks.

Quantities of rare species can be estimated from a knowledge of their requirements and the possible recognition of these habitats on the photographs. Future use of the mosaic and maps, it is hoped may also relate locations of rare species to the boundaries and transition zones where they often occur.

N.B.

More detailed description of the techniques used are given in C.E.R.S. Research Paper 1. It is now intended to mass produce copies of the vegetation map which should be available shortly.